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AN EVALUATION OF THE FRUITTREE LEAFROLLER SITUATION, ARROWHEAD RANGER DISTRICT, SAN BERNARDINO NATIONAL FOREST

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ABSTRACT

Ground and aerial surveys of fruittree leafroller (Archips argyrospilus) defoliated areas were conducted in July and August, 1983, on the Arrowhead Ranger District. Defoliation was observed over approximately 14,500 acres in areas between Sugarpine Mountain/Silverwood Lake and Running Springs, an increase over the 2,000 acres reported in 1982. Most of the area had light (< 50%) to moderate (50-80%) defoliation; heavy (> 80%) defoliation was observed on scattered, individual trees and in localized areas covering an estimated 1,500 to 2,000 acres. Limited egg mass counts indicate that 1984 defoliation levels should be about the same or somewhat higher than in 1983, barring significant population reduction by natural factors. The pest management alternatives of 1) continuing current management direction, 2) direct control of the fruittree leafroller either area-wide or on an individual tree basis and 3) integration of fruittree leafroller and other pest considerations with the management of oaks and associated vegetation, are discussed.

INTRODUCTION

Since the early 1970's, the fruittree leafroller (FTLR), Archips argyrospilus (Lepidoptera:Tortricidae) has caused noticeable defoliation to oaks on lands of all ownerships in the San Bernardino Mountains, principally in areas between Sugarpine Mountain/Silverwood Lake and Running Springs. Norm Nass, Resource Forester, Arrowhead Ranger District and John Wenz, Forest Pest Management (FPM) Staff, conducted a ground survey of FTLR defoliated areas on July 15-17, 1983 which was followed by an

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aerial survey of the same areas on August 16. The purpose of this report is to document the results of the 1983 survey, summarize information available from previous FTLR outbreaks in the San Bernardino Mountains and discuss FTLR management alternatives for use under various land and resource management objectives.

SURVEY RESULTS - 1983

Observations

Oak defoliation was observed over about 14,500 acres (Figure 1), a considerable increase over the 2,000 acres reported in 1982 (These are gross acres; oaks are estimated to cover about one-third of the forested areas on the San Bernardino National Forest and about the same proportion of the area within the defoliation boundaries is occupied by oaks, often in a mixture with conifers. For the purposes of this report, arbitrary, qualitative defoliation classes are defined as light, < 50% of the entire tree defoliated, moderate, 50-80%, and heavy, > 80%). Throughout the infested area, individual moderately to heavily defoliated trees could be found, but overall, much of the area evaluated appeared to have light to moderate defoliation. No evidence of current defoliation was observed in the Rouse Meadows area along road 2N26 or in the Saddle Flats area along 2N33. Very little evidence of FTLR activity was observed in the Blue Jay - Tunnel 2 Ridge or the Deer Lick - Arrowbear areas.

Areas of heavy localized defoliation, covering an estimated 1,500-2,000 acres, were observed on the NW side of Heaps Peak (T.2N., R.3W., parts of sections 13, 14 and 25, to Shake Creek), Valley of the Moon (T.2N., R.4W., parts of sections 13, 14 and 24) and on the north side of Sugarpine Mountain (T.2N., R.5W., parts of sections 14 and 15). A brief ground check of an area near Sugarpine Mountain along 2N49 on August 16, revealed considerable twig and branch dieback on the oaks, but little evidence of typical FTLR defoliation and no FTLR egg masses (old or new) were found. However, just south of this area, in section 13, old (1982) egg masses were easily found and FTLR defoliation was evident. In addition, an examination of oak defoliation in the Pine Flat area south of Monument Peak (Cajon Ranger District) indicated branch dieback, leaf blotch and leaf miner activity, but not FTLR.

Comparatively little current defoliation was seen in the Lake Gregory, Valley of Enchantment, Cedarpines and Crestline areas although twig and branch dieback attributable, at least in part, to past defoliation was evident. No reports of FTLR were received from two areas on the San Gorgonio Ranger District, Forest Falls, which had visible defoliation reported in 1979, 1980 and 1981 and Angeles Oaks, which had defoliation in 1980 or the Sansevaine area (Cajon Ranger District) defoliated in 1979 and 1980.

Egg Mass Survey

New (1983) and old (1982) egg masses were counted at seven sites throughout the infestation area to help estimate the potential for defoliation in 1984. One branch from each of five trees was examined in each area. The number of new and old egg masses, branch length, DBH, height and an estimate of percent defoliation were recorded for each tree. The ratio of new to old egg masses can be used to get an indication of population trend from one year to the next. Four of the seven sites had a positive new to old egg mass ratio and at one site (#7), the ratio was essentially 1:1 (Table 1). At site #3, where about 35% fewer new (compared to old) egg masses were found, the host was canyon live oak, Quercus chrysolepis, rather than California black oak, Q. kelloggii, the most common FTLR host in the San Bernardino Mountains. Site #5 was in an area of generally heavy defoliation, and it is possible that relatively few new egg masses were laid due to stress induced, at least in part, by starvation. Totals for all areas combined were 417 new and 316 old egg masses for an overall new to old ratio of 1.3:1.

Discussion

Defoliation associated with the FTLR was observed in the San Bernardino Mountains in 1951-53 and, since the early 1970's, has been consistently reported from areas between Sugarpine Mountain/Silverwood Lake and Running Springs. The estimated gross acres of annual defoliation since 1973 are given in Figure 2 and maps outlining the general locations of defoliation between 1979 and 1982 are given in Figures 3-6 (the maps do not include defoliation reported from the Angeles Oaks, Forest Falls or Sansevaine areas). As with many defoliators, FTLR populations and defoliation levels can fluctuate markedly from year to year. Although some areas, like Lake Gregory and the Cedar Glen - Hook Creek vicinity, seem to have some defoliation almost every year, there does not appear to be any consistent year to year pattern of occurrence. The increases and decreases in levels of defoliation seem to result from population changes that occur in place rather than from annual, large-scale, adult migration from area to area.

The factors that cause FTLR populations/defoliation to fluctuate are not known. Quantitatively valid sampling procedures have not been developed for the FTLR and egg mass collections, as described above, must be interpreted with caution. In 1980, a limited egg mass survey indicated approximately equal numbers of old (1979) and new (1980) egg masses. The area defoliated in 1980 was subsequently determined to have increased about 10,000 acres over 1979. Given this uncertainty, the results of this year's egg mass survey indicate that about the same or somewhat higher levels of defoliation should occur next year, assuming population levels are not significantly reduced by natural factors.

MANAGEMENT ALTERNATIVES

Over the past several years, the Forest Service, state and local agencies as well as private groups and individual homeowners have been concerned about the effects of FTLR defoliation and how to mitigate those effects. The following management alternatives and the consequences of their implementation must be considered within the context of management objectives. Management concerns can and do vary from an individual tree, to a few trees in a particular location, to one or a few stands over limited areas, to the management of forest resources over large areas. Each alternative should be evaluated from the standpoint of biological efficacy, economic efficiency and environmental effects.

1. Continue current management direction. Under this alternative, the FTLR will likely continue to cause periodic defoliation at levels similar to those seen since 1973 in the San Bernardino Mountains. Similarly, consequent oak mortality and growth loss should be about the same as that which has occurred over the past 10 years. Widespread mortality does not seem likely, but continued mortality of scattered individual trees and to stands over limited areas may be expected. This prognosis is based on the lack of widespread oak mortality in the infestation area over the last ten years and observations of FTLR activity in other parts of California where large-scale mortality has not occurred. In addition, oaks, compared to conifers, have the ability to survive periods of reduced growth and stress and respond relatively rapidly when conditions improve. Annual fluctuations of defoliation intensity in a given area provide affected oaks with the opportunity for at least partial recovery.

The radial and height growth loss attributable to FTLR is, by itself, important only if specific annual or periodic growth related objectives are affected. However, growth loss does, presumably, reduce tree vigor and contribute to the decline of the tree.

Trees most likely to die or suffer increased growth loss and decreased vigor are those severely defoliated for two or more successive years and/or that are under additional stress. Factors observed in the San Bernardino Mountains that can cause or contribute to stress on oaks include oxidant air pollutants, true mistletoe, an unidentified canker dieback, Armillaria root disease, drought, competition and old age. In many of the areas observed, the oaks are growing in association with conifers and woody shrubs. Under worst case conditions, where considerable oak mortality occurs in a given area, it is likely that other vegetation would occupy the site relatively quickly. In mixed oak-conifer stands, most conifers should eventually grow taller than the oaks, shading them out, and thus, on some sites at least, the FTLR may only be hastening or enhancing natural succession.

The expected oak mortality should not significantly affect water quality and quantity since other vegetation should increasingly occupy the sites as the oaks die out, thus minimizing potential erosion problems. Oak mortality, limb and branch dieback and associated breakage contribute an unknown (but potentially measurable) amount of biomass to existing fuel

loads. Standing dead oaks increase potential "fuel ladder" problem situations. The San Bernardino Mountains are classified as a high fire hazard area due to an abundance of extremely hazardous fuels (chaparral), seasonally severe fire weather conditions and very high human use. Given the already extreme fire hazard situation, it is conjectural as to how critical additional FTLR-related fuel loading is to the probability of occurrence or severity of a fire. The effect of expected mortality on wildlife should be minimal since localized oak mortality could negatively affect some species while favoring others.

Another consideration is a potential problem to conifer regeneration due to the shoestring fungus, Armillariella mellea. This fungus is commonly associated with oaks, but causes few problems as long as the host remains healthy. However, the fungus can colonize the roots and stumps of dead, dying, or cut oaks which act as food bases for the fungus. The fungus can then spread to living trees through root contact or by rhizomorphs and may eventually girdle and kill conifer seedlings and saplings in the vicinity of the infected tree or stump. Conifer seedlings are particularly susceptible to infection, while trees more than 15 years old usually show some resistance. The concern is that mortality and dieback caused by FTLR-related defoliation will result in an increase of Armillaria and create problems in regenerating conifers near the infected oaks. Armillaria can quickly colonize oaks that die rapidly or healthy trees that are cut (and do not sprout) because of the immediate availability of a large food base. However, it is not clear how fast, with what frequency or to what extent Armillaria will colonize trees that die after declining over a period of years, as is frequently the case with the FTLR, because such trees may not provide as large a food base at any given time. In any case, the effects would esentially be limited to conifer regeneration in the vicinity of dying, infected oaks, and its importance will depend on how critical such regeneration is to management objectives (see Alternative 3, below). It is likely that oaks or other hardwoods could be regenerated near the infected trees.

Additional management considerations may become important if the concern is protecting high value individual trees or managing oaks over specific limited areas, including campground and administrative or other developed sites. Under such circumstances, even single tree mortality may be significant and could result in some potential loss in property value as well as tree removal (possibly mitigated to some extent by use of the tree for firewood) and replacement costs. In addition, defoliation could contribute to limb and branch dieback resulting in increased hazard and subsequent cost of reducing the hazard. Also, the effect of defoliation in the spring, despite the potential for refoliation, could temporarily reduce aesthetic values (aesthetics may also be an area-wide concern) and summer shading capacity.

2. Direct control - insecticides.

a) Area-wide aerial application. Aerial application of an insecticide appears to be the only way of treating all or large sections of an infestation at one time. Limited, individual tree, field tests indicate that several chemicals including sevin 80S, orthene 75S, imidan 50WP,

malathion 8EC and diazinon 4EC, if applied properly and in a timely manner, could limit defoliation to 20% or less of the current foliage complement. However, the relationships between given levels of defoliation and the probability of mortality or amount of growth loss are not known and thus the benefits of a given level of foliage protection, beyond aesthetic considerations, are hard to determine with accuracy. Bacillus thuringiensis (Bt), a bacterium, is also available. Use of Bt may result in less foliage protection but, because of its specificity to lepidopterous larvae, has minimal effects on non-target species. Aerial application costs would probably run between $12 and $20/acre, depending on such factors as the insecticide selected and the size of the area to be treated.

In considering the need for area-wide control, a basic determination is that if some action is not taken, the damage (as discussed above) to resources caused by the FTLR will be unacceptable in terms of management goals and objectives and, further, that implementing direct control will cause the damage to be reduced to acceptable levels. The uncertainty in predicting, based on the current limited knowledge of FTLR population dynamics, what growth loss and mortality will occur in any given time period, make this determination difficult at best. Problems in quantifying both damage loss and resource benefits could complicate economic efficiency calculations. In addition, sampling problems, the discontinuous distribution of affected stands, mixed ownerships, the proximity of domestic water supplies to the area of infestation and other public health concerns associated with the level of human activity in the general area, must be considered and may make area-wide application infeasible. Other potential environmental problems such as the effect of insecticides on non-target organisms must also be considered. Further, direct FTLR control would not mitigate other factors, as noted above, that may be adversely affecting the oaks.

b) Individual tree ground application. The insecticides discussed in (a) above are also relevant to this alternative. However, ground application allows for greater control of timing and delivery of the insecticide and reduces, but does not eliminate, all the logistical, public health and environmental problems discussed above that are associated with area-wide application. Individual trees may also be treated with a dormant oil spray during the winter (January-February) prior to bud break, to kill the overwintering eggs.

The importance of particular high value tree(s) to management goals and objectives for specific limited areas may be more readily assessed than for large areas. Similarly, FTLR-related damage, from mortality to reduced aesthetics, can be judged more easily or realistically (than for large areas) as can the costs and benefits of a treatment. Estimates of potential damage to specific trees based on an evaluation of current tree condition, egg mass and/or larval density estimates, even in the absence of reliable sampling procedures, should be easier to conduct and more dependable than similar estimates for extensive areas. Although adult dispersal does not appear to be a significant factor in area-wide population movements, local dispersal does occur and treated trees may become reinfested in subsequent years through immigration (as well as from eggs/larvae missed by the treatment). As with area-wide direct

control, individual tree treatment will not mitigate other factors adversely affecting the oaks.

3. Oak Management. This alternative does not affect the FTLR directly, but aims to mitigate or reduce the impacts of FTLR-related damage. The basic assumptions are relevant regardless of the size of the management area or what the management objectives are and include consideration of factors, in addition to the FTLR, that influence oak management. Repeated, heavy, defoliation by the FTLR can cause serious growth reduction and kill otherwise healthy oaks, but by managing oaks and associated vegetation so as to maintain vigorously growing trees, those individuals that are defoliated should be better able to withstand the damage and increase chances of recovery. Damage to roots and/or disruption of soil and water relations due to construction, trenching, laying asphalt or concrete over large areas or backfilling dirt or rocks around the tree base should be minimized or prevented. Pruning of dead and dying branches will reduce hazard and also may prevent wood boring insects from attacking adjacent healthy portions of the tree. Infection by true mistletoe can also weaken trees and control, particularly with heavily infected trees, should be considered. Managing the vegetation associated with the oaks and maintaining stocking levels appropriate to the site will also help stand vigor. Encouraging species diversity will reduce dependence on any particular species and may provide more flexibility in management decisions.

Where oaks are dying or declining in a particular area from a combination of FTLR and other causes, removal of such oaks through a commercial fuelwood or other type of sale might be considered. This would, in addition to providing a product, have the benefit of reducing the fire hazard associated with the dead and dying oaks. Removal of the oaks would also provide the opportunity to regulate species composition to meet management objectives through release of species already on site and/or artificial regeneration. From an entomological standpoint, reducing the proportion of oaks in a given stand would reduce FTLR-related problems, but consideration should be given to potential pest problems associated with the replacement species, particularly Jeffrey and ponderosa pines. Proper management will reduce the potential of such pest problems to acceptable levels, but the effects of periodic droughts and susceptibility to oxidant air pollutants, particularly on sites exposed to heavy concentrations, should also be considered. In addition, some erosion, depending on site, and damage to leave trees may result from harvest operations. As noted above (Alternative 1), cutting oaks can potentially result in a problem with Armillaria. If oaks are cut and not allowed to sprout, a large food base is created for Armillaria to utilize and subsequently interfere with conifer regeneration in the vicinity of the stump. This is probably most serious when healthy trees are cut and less serious if the trees cut are weak and have suffered some root dieback over a period of time, as may be the case with trees that have periodically been defoliated by the FTLR. The problem can largely be avoided if the oaks are allowed to sprout and managed as part of the stand. In addition, the alternative of stump removal, either mechanically or by burning, might be considered in high value situations.

TABLE 1. FRUITTREE LEAFROLLER EGG MASS SURVEY, JULY 25-27, 1983, ARROWHEAD RANGER DISTRICT, SAN BERNARDINO NATIONAL FOREST

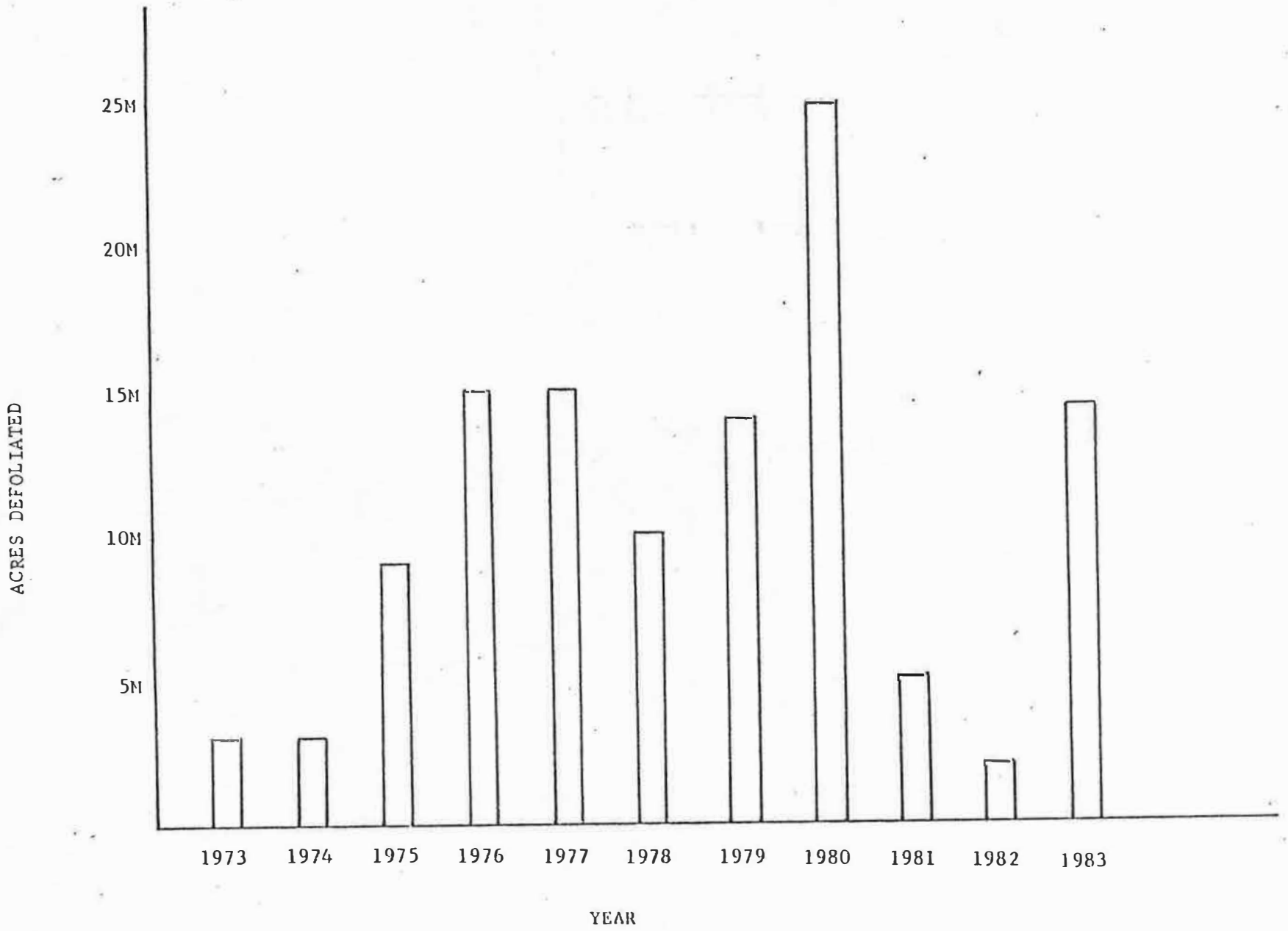
SITE	TREE NO.	EGG MASSES NEW (1983)	EGG MASSES OLD (1982)	NEW-OLD EGG MASS RATIO	BRANCH LENGTH (FT)	1983 EGG MASSES/FT BRANCH LENGTH	DBH (INCHES)	HEIGHT (FT)	PERCENT DEFOLIATION
1. Shake Creek	1	19	8	2.4:1	7'0"	2.7	2	7	40
T.2N., R.3N., S13	2	20	8	2.5:1	7'6"	2.7	4	12	25
	3	8	19	0.4:1	7'4"	1.1	10	30	60
	4	25	21	1.2:1	11'5"	2.2	12	50	60
	5	17	13	1.3:1	7'6"	2.3	10	35	50
Total		89	69	1.3:1	40'9"	2.2			
2. Highway 138	6	40	23	1.7:1	5'2"	7.8	12	43	60
T.2N., R.4W., S16	7	34	30	1.1:1	7'2"	4.7	10	30	90
	8	39	21	1.9:1	5'	7.8	10	30	60
	9	0	1	- - -	3'8"	0.0	2	12	75
	10	24	14	1.7:1	5'4"	4.5	4	20	70
Total		137	89	1.5:1	26'4"	5.2			
3. Cottonwood	11	5	11	0.5:1	4'10"	1.0	4	20	25
Station	12	3	5	0.6:1	4'2"	0.7	2	15	25
T.2N., R.5W., S1	13	0	7	- - -	3'0"	0.0	4	12	25
	14	17	15	1.1:1	5'3"	3.3	4	15	25
	15	0	1	- - -	4'8"	0.0	2	15	25
Total		25	39	0.6:1	21'11"	1.1			
4. East Miller	16	28	3	9.3:1	5'5"	5.2	4	20	45
Canyon	17	17	4	4.3:1	5'5"	3.1	6	30	45
T.2N., R.4W., S12	18	15	5	3.0:1	4'2"	3.7	2	20	45
	19	34	10	3.4:1	5'2"	6.7	6	25	45
	20	1	5	0.2:1	4'5"	0.9	6	30	45
Total		95	27	3.5:1	24'7"	3.9			
5. Valley of	21	6	12	0.5:1	4'0"	1.5	14	35	70
the Moon	22	3	16	0.2:1	4'8"	0.6	2	10	80
T.2N., R.4W., S24	23	1	7	0.1:1	5'2"	0.2	12	35	55
	24	1	12	0.1:1	4'1"	0.2	6	25	65
	25	14	14	1.0:1	5'1"	2.7	28	65	40
Total		25	61	0.4:1	23'0"	1.1			

TABLE 1. (CONT)

SITE	TREE NO.	EGG MASSES NEW (1983)	EGG MASSES OLD (1982)	NEW-OLD EGG MASS RATIO	BRANCH LENGTH (FT)	1983 EGG MASSES/FT BRANCH LENGTH	DBH (INCHES)	HEIGHT (FT)	PERCENT DEFOLIATION
6. Heap's Heli-port	26	7	5	1.4:1	5'0"	1.4	16	30	45
	27	6	1	6.0:1	5'6"	1.1	4	10	15
T.2N., R.3W., S25	28	9	5	1.8:1	4'0"	2.3	6	15	35
	29	3	0	- - -	3'0"	1.0	6	20	10
	30	4	2	2.0:1	3'6"	1.1	22	25	15
Total		29	13	2.2:1	21'0"	1.4			
7. Running Springs	31	2	2	1.0:1	3'6"	0.6	48	55	20
	32	2	5	0.4:1	4'8"	0.4	36	45	30
T.2N., R.2W., S32	33	6	3	2.0:1	5'1"	1.2	28	30	15
	34	3	4	0.8:1	4'5"	0.7	16	20	15
	35	4	4	1.0:1	4'2"	1.0	26	35	15
Total		17	18	0.9:1	21'10"	0.8			

The Pinnacles
Cleghorn Mtn.
Cajon Mtn.
Sugarpine Mtn.
Monument Pk.
Arrowhead Pk.
Lake Arrowhead
Shay Mtn.
Little Shay Mtn.
Deer Mtn.
Mill Pk.
McKinley Mtn.
Harrison Mtn.
SAN BERNARDINO
Highland
Muscoy
Patton
Del Rosa
Devore
Sycamore Flat
Arrowhead Highlands
Rimforest
Skyforest
Green Valley Lake
Crestline
Cedarpines Park
Valley of Enchantment
Lake Gregory
Twin Peaks
Pilot Rock
Saddle Flats
Mt. Marie Louise
Stove Flats
Bacon Flats
Ash Mdws.
Crab Flats
Heaps Pk.
Seymour Flat
Hunting Springs
Parcolation Basin
Shandin Hills
Tokay Hill
Devore Heights
Jobs Pk.
Breezy Pt.
Cajon Pass
Banning
Cleghorn Pass
Sugarpine Spr.
Cedar Springs Dam
Lake Arrowhead
Green Valley Lake
Arrowbear Lake
Mt. "R"
Holcomb
Ingham Pk.
Muddy Spr.
Devil's Hole
Mojave River Forks Flood Control I
Mojave River
Mojave Valley
Cajon Creek
Lytle Creek
Waterman
Sycamore
Strawberry Cr.
Barton Rd.
Foothill Blvd.
Union Pacific RR
Santa Fe RR
Kimbark Ave.
Waterman Ave.
Sterling Ave.
Del Rosa Ave.
Highland Ave.
Boulder Ridge
Cleghorn Ridge
Valley
Tunnel Ridge
Miller
Willow
Kinsley
Meadow
Oak
Hot Spr.
Warm
Mill Creek
Barton Cr.
Sand Cr.
Schenk Cr.
Hermick
Fredalba
Governor
Santa
Lytle
Rialto
Hass
Wells
Pico
Rialto Cr.
Lytle Creek
Cajon Creek
Sycamore Cr.
Strawberry Cr.
Mill Creek
Barton Cr.
Sand Cr.
Schenk Cr.

FIGURE 2. ACRES OF FRUITTREE LEAFROLLER DEFOLIATION, SAN BERNARDINO MOUNTAINS, 1973-1983.



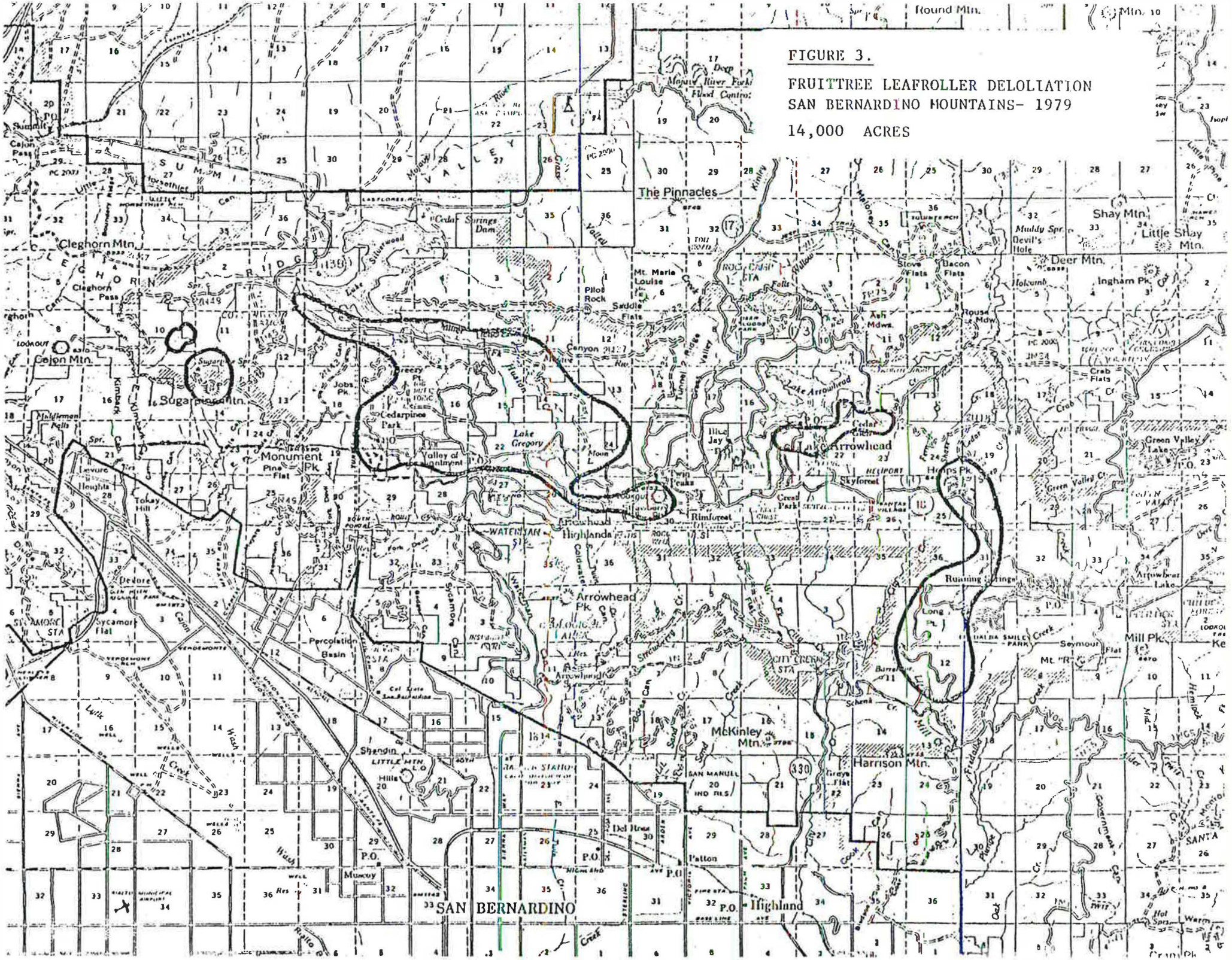


FIGURE 3.
FRUITTREE LEAFROLLER DELOLIATION
SAN BERNARDINO MOUNTAINS- 1979
14,000 ACRES
The Pinnacles
Cleghorn Mtn.
Cajon Mtn.
Sugarloaf Mtn.
Monument Pk.
Pine Flat
Lake Gregory
Lake Arrowhead
Deer Mtn.
Shay Mtn.
Little Shay Mtn.
Ingham Pk.
Arrowhead Pk.
Highlands
Rimforest
Skyforest
Running Springs
Arrowbear Lake
Mill Pk.
McKinley Mtn.
Harrison Mtn.
Shandin
Muscoy
SAN BERNARDINO
Highland
Patton
Sycamore Flat
Percolation Basin
Twin Peaks
Valley of Enchantment
Cedarpines Park
Green Valley Lake
Seymour Flat
Grays Flat
Del Rosa
Round Mtn.

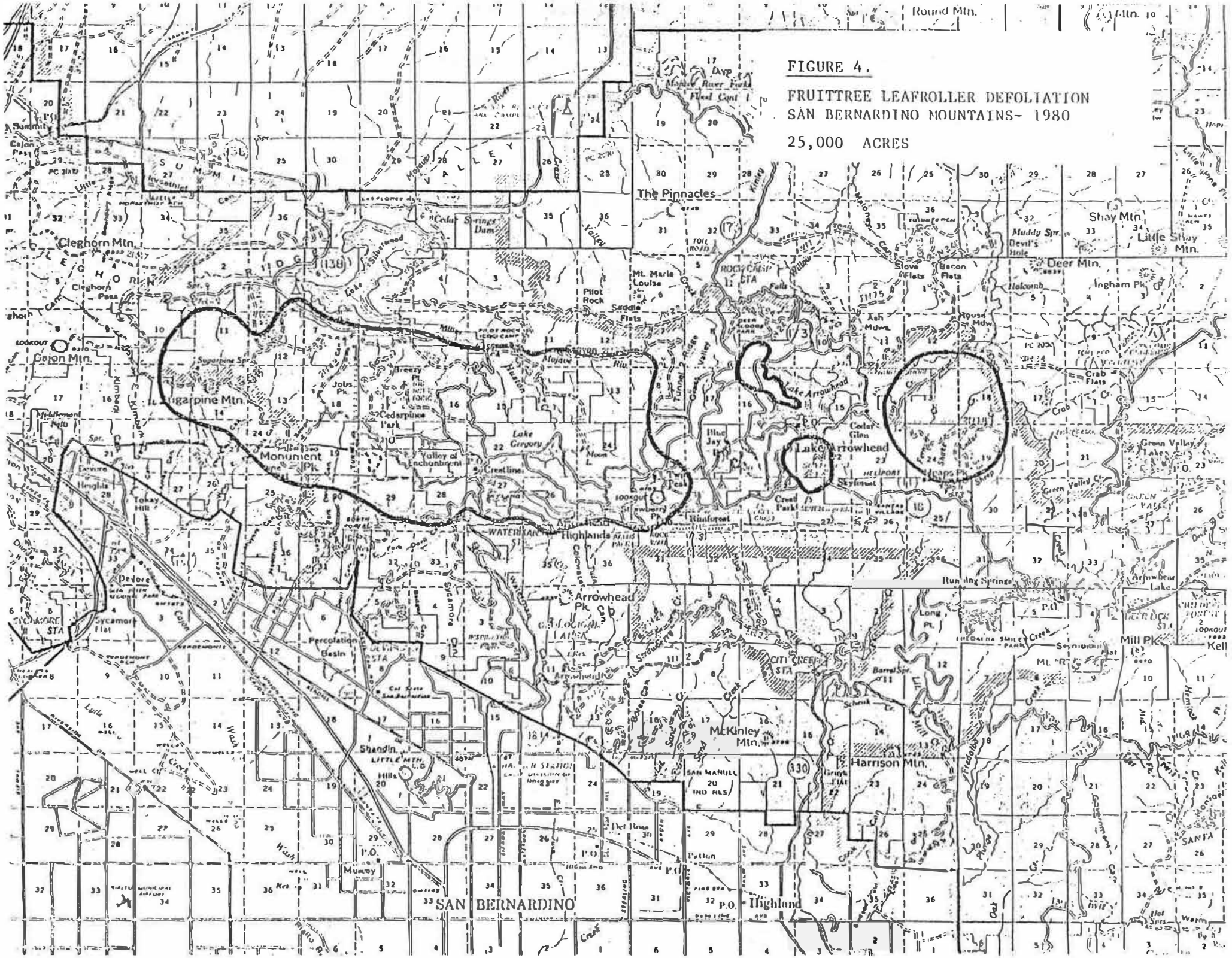


FIGURE 4.
FRUITTREE LEAFROLLER DEFOLIATION
SAN BERNARDINO MOUNTAINS- 1980
25,000 ACRES
Round Mtn.
The Pinnacles
Shay Mtn.
Little Shay Mtn.
Deer Mtn.
Cleghorn Mtn.
Colon Mtn.
Sugarpine Mtn.
Monument Pk.
Lake Arrowhead
Highlands
Arrowhead Pk.
Mill Pk.
McKinley Mtn.
Harrison Mtn.
SAN BERNARDINO
Highland
Devore
Sycamore Flat
Shandin
Running Springs
Arrowbear Lake
Green Valley Lake
Crab Flats
Ingham Pk.
Pilot Rock
Saddle Flats
Mt. Marie Louise
Cedarpine Park
Valley of Enchantment
Blue Jay
Cedar Glen
Crestline
Twin Peaks
Skyforest
Percolation Basin
Sand Canyon
Waterman Canyon
Cajon Pass
Summit
Cleghorn Pass
Lake Gregory
Jobs Pk.
Breezy Pt.
Tokay Hill
Middlemont Mills
Muddy Spr.
Devil's Hole
Slover Flats
Bacon Flats
Ash Mdws.
Rouse Mdw.
Holcomb
Barrel Spr.
Schenk
Muscoy
Patton
Del Rosa
Hills
Oak
Hemlock
Pine
Fredalba
Seymour
Long Pt.
Kell
SANTA

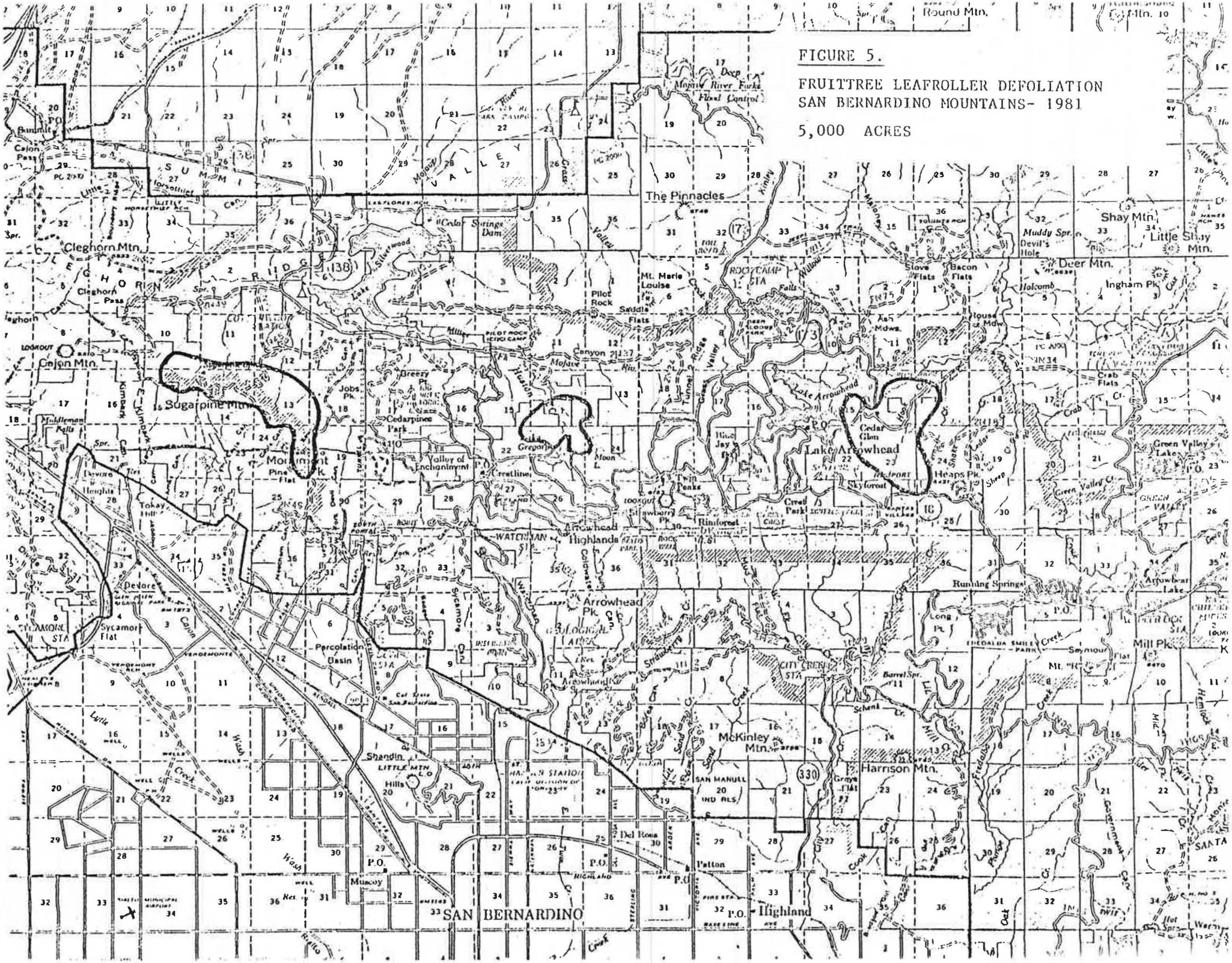


FIGURE 5.
FRUITTREE LEAFROLLER DEFOLIATION
SAN BERNARDINO MOUNTAINS- 1981
5,000 ACRES
Round Mtn.
The Pinnacles
Shay Mtn.
Little Shay Mtn.
Deer Mtn.
Ingham Pk.
Cleghorn Mtn.
Cajon Mtn.
Sugarpine Mtn.
Monument Pk.
Lake Arrowhead
Green Valley Lake
Arrowhead Highlands
Arrowhead Pk.
Running Springs
Arrowbear Lake
Mill Pk.
Sycamore Flat
Pedore
Percolation Basin
Shandin Hills
McKinley Mtn.
Harrison Mtn.
Del Rosa
Muscoy
SAN BERNARDINO
Highland
Patton

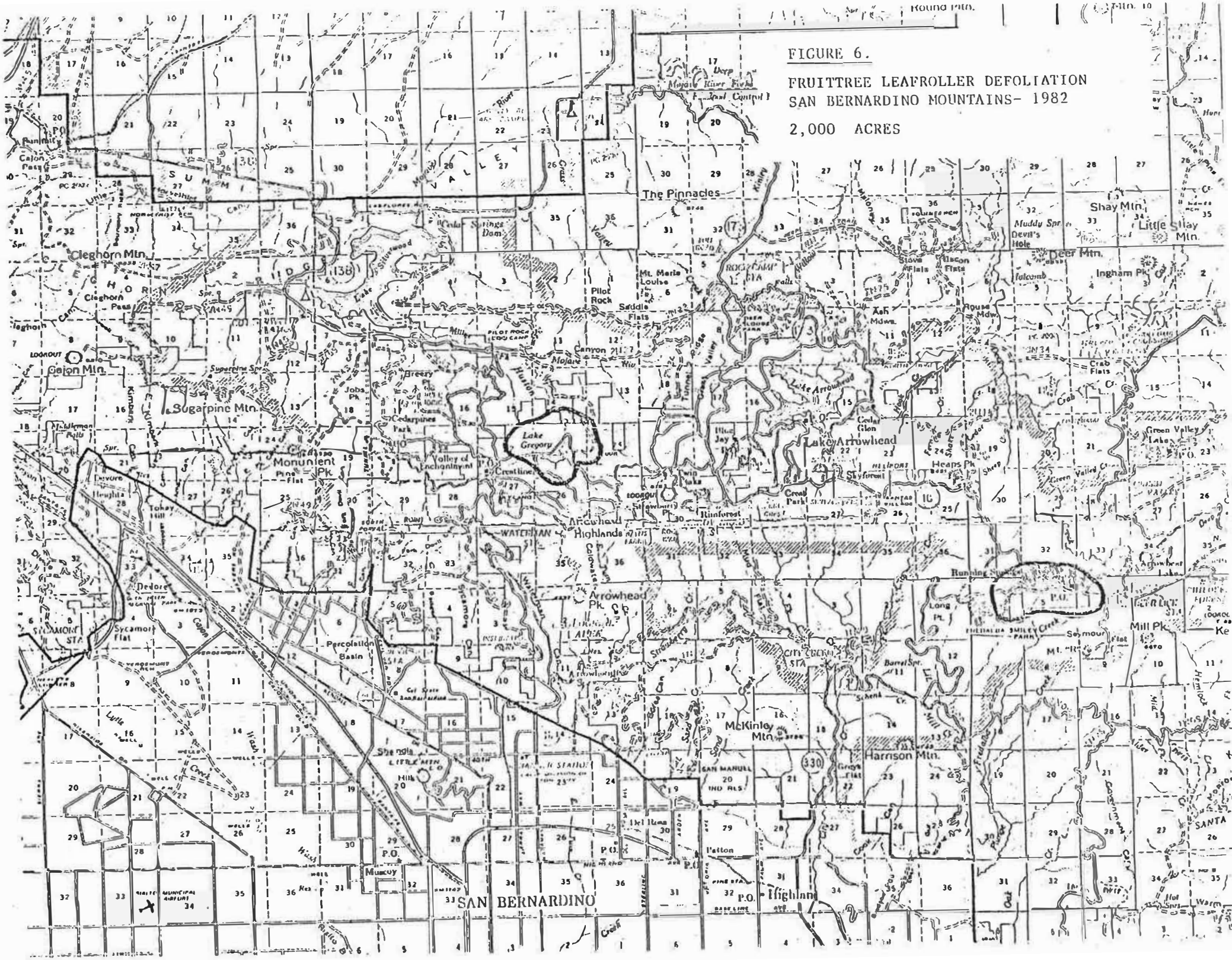


FIGURE 6.
FRUITTREE LEAFROLLER DEFOLIATION
SAN BERNARDINO MOUNTAINS- 1982
2,000 ACRES
The Pinnacles
Cleghorn Mtn.
Celon Mtn.
Sugarpine Mtn.
Monument Pk.
Lake Gregory
Lake Arrowhead
Crestline
Arrowhead Highlands
Waterman
Arrowhead Pk.
Dedora
Sycamore Flat
Percolation Basin
Shandin Hills
McKinley Mtn.
Harrison Mtn.
Shay Mtn.
Little Shay Mtn.
Deer Mtn.
Ingham Pk.
Mill Pk.
Heaps Pk.
Green Valley Lake
Muscoy
SAN BERNARDINO
Highland